Warming seas: Climate change's toll on tropical fish

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A spiny chromis damselfish (Acanthochromis polyacanthus), one of the species the researchers studied, in its natural environment, the Northern Great Barrier Reef in Australia. The increasing frequency, duration, and magnitude of marine heatwaves can have detrimental effects on coral reefs and resident fish populations. Credit: Tane Sinclair-Taylor

In 2016, ocean temperatures soared, devastating the corals of Australia's Great Barrier Reef. As the frequency, duration and magnitude of these marine heatwaves increases due to human-induced climate change, scientists have yet to fully grasp the physiological, behavioral, and long-term consequences for wild fish populations.

Researchers in the Marine Climate Change Unit at the Okinawa Institute of Science and Technology Graduate University (OIST), in collaboration with scientists from the ARC Centre of Excellence for Coral Reef Studies, James Cook University in Australia and the University of Hong Kong, have studied patterns of gene expression in five species of coral reef fish collected at different points before, during, and after the 2016 heatwave. Through these analyses, the scientists identified species-specific physiological responses to the heightened temperatures; these responses were influenced by the intensity and duration of the heatwave.

These changes likely signal long-term consequences for the fitness of fishes—and the health of marine ecosystems—as extreme heat events increase in frequency. The results of the study are published in *Science Advances*.

Collecting and analyzing fish

To carry out their research, the scientists sampled five species from two families of coral reef fish from Lizard Island, off the northeast coast of Australia. The researchers began sampling before the predicted heatwave in December, then at the start of the heatwave in February 2016, finishing after the fish had endured prolonged exposure to high temperatures in July 2016.

The researchers studied damselfishes and cardinalfishes, which are abundant and relatively easy to catch. In addition, damselfish are diurnal, while cardinalfish are nocturnal, meaning they swim and eat at night

when temperatures are lower.

A school of damselfish inhabiting a healthy coral colony in the Northern Great Barrier Reef in Australia. Credit: Tane Sinclair-Taylor

The scientists froze the specimens and transported them back to the lab. Upon analyzing gene expression patterns in the livers of the fish, they found molecular changes related to metabolism, stress, and respiration, tied to both short-term and prolonged heat exposure.

Their molecular evidence suggests that different tropical fishes respond to warming in different ways, meaning that genetic background has a significant influence on the way that fish can acclimatize or adapt to

climate change; some fish are more vulnerable than others.

"These varied responses are important because when scientists do experiments, or target commercial species, we cannot generalize based on geography or on one or two species that have been studied in the lab," said Professor Timothy Ravasi, the leading author of the study. "This has important ramifications for policy makers and for the fishing industry."

Regardless of species, the researchers found that the physiological responses of the fish to the heatwaves depended on the intensity and duration of the heatwaves.

Moving forward, Ravasi and his team hope to continue examining the immediate consequences of anthropogenic climate change by studying how repeated episodes of warming could influence fish and their long-term adaptation. Ravasi intends to simulate heatwaves in controlled environments to see how different temperatures and different periods of exposure affect fish.

Although it's important to examine the long-term implications of climate change, Ravasi said, his paper emphasizes the importance of looking at the short-term.

"Over time, the fish may adapt to rising temperatures, or they'll migrate to cooler waters," he said. "But these heatwaves are happening now, and it's necessary for the field to understand the immediate consequences.

More information: M.A. Bernal el al., "Species-specific molecular responses of wild coral reef fishes during a marine heatwave," *Science Advances* (2020). DOI: 10.1126/sciadv.aay3423 , advances.sciencemag.org/content/6/12/eaay3423